

## **Early Student Support for the Study of Inertial Motions in the Arctic Ocean**

Luc Rainville  
Applied Physics Laboratory  
1013 NE 40<sup>th</sup> Street  
Seattle, WA 98105  
phone: (206) 685-4058, fax: (206) 543-6785  
email address: [rainville@apl.washington.edu](mailto:rainville@apl.washington.edu)

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### **LONG-TERM GOALS**

The decreasing trend in minimum sea-ice extent in the Arctic Ocean has been a topic of concern with far reaching effects. There is good reason to believe that the Arctic Ocean will become a more active ocean, with larger surface waves and more intense internal wave activity (Rainville et al., 2011). Particularly in the marginal zone, the processes controlling the response of the ocean to wind forcing span a wide range of spatial and temporal scales. In this project, we use a combination of several existing instruments, satellite products, simple models, and emerging new technology to study the internal wave field in the Arctic Ocean, and the feedback processes between internal wave energy and stratification.

### **OBJECTIVES**

This project supports Ms. Hayley Dosser, a graduate student in the University of Washington Oceanography program. Her work involves a combination of the analysis of existing observational data and numerical modeling to quantify internal wave energy and propagation in the Arctic Ocean. The relationships between the internal wave field and the atmospheric and tidal forcing, as well as with the ice cover, are being investigated. As in lower latitudes, the vertical mixing associated with the inertial waves impacts the stratification - the spatial and temporal variability of the inertial wave field are also reflected in an inhomogeneous distribution of the vertical diffusivity. This directly impacts how temperature, salinity, stratification, and other properties (tracers, nutrients, etc.) evolve in the upper Arctic Ocean.

As the near-inertial waves are propagating downward in the Canada Basin, they encounter the thermohaline staircase at the top of the Atlantic Water. A goal of this project is to investigate the interactions between the complex step-like stratification and the waves.

### **APPROACH**

Initially, Dosser's project focuses on analyzing the salinity and temperature profiles from the drifting Ice-Tethered Profilers in the Beaufort Gyre region to quantify the near-inertial internal wave field. Ice-Tethered Profiler (ITP) data from the Canada Basin. Previous observations of internal waves in the Arctic, typically from ships or ice camps, have been spatially and temporally limited, lacking year-

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round or multi-year timeseries. The ITPs have collected year-round timeseries for the last decade, potentially providing an excellent record of the spatial and temporal evolution of internal waves in the region in the upper 750 m of the water column.

However, due to poor time resolution and irregular sampling, near-inertial frequency signals are only marginally resolved. The initial part of this project (Dosser's UW Master Thesis) demonstrates that by using careful fitting ideal sinusoidal waves to the measured isopycnal displacements, estimates of the slowly varying amplitude of the inertial wave field can be obtained (as well as the associated uncertainty).

## **WORK COMPLETED**

A manuscript describing the technique and initial results for one ITP is nearly completed and about to be submitted for publication.

For illustration, Figure 1 shows the depth-averaged vertical displacement for ITP6, which was deployed in Sept. 2005 and sampled across the central Canada Basin for over one year. The isopycnal displacements are scaled by the square root of the buoyancy frequency to mitigate the variations in the wave amplitude with depth caused by the mean background stratification. There is significant wave activity at all depths, but particularly just below the Atlantic Water maximum (near 400m) and very near the surface. Periods of high amplitude waves are observed every few weeks, and are distributed fairly evenly over all latitudes and longitudes traversed by the ITP (not shown). It is doubtful that topographically generated waves play a large role in this location. It is more likely that the waves are predominantly caused by ice motion resulting from surface wind forcing, with some caused by the passage of eddies or other generation mechanisms yet to be determined. There is a significant seasonal cycle associated with the scaled vertical displacement amplitude of the waves at all depths, shown in Figure 1. This seasonal cycle has a peak in mid-August, and a minimum in mid-February, suggesting that thicker, more prevalent sea-ice cover damps wave motions.

## **RESULTS**

This work demonstrate that it is possible use the ITP dataset to extract and quantify the near-inertial internal wave field at all depths, including in regions of complex stratification such as the double-diffusive staircase found in the Canada Basin. We see a clear relationship between the wind forcing and the internal wave energy in the water column. Ms. Dosser is at the beginning of her 3<sup>rd</sup> year in the University of Washington graduate program. She will defend her Master's this Fall, and continue with the analysis of the entire ITP dataset that has been collected in the Canada Basin.

## **IMPACT/APPLICATIONS**

The obvious next step is to analyze the other ITPs deployed in the Canada Basin and obtain a multi-year, regional climatology of the inertial wave field. Since all the ITPs are anchored in multi-year ice floes, the inertial wave field will be that of an (at least marginally) ice-covered ocean. Ms. Dosser is actively working on this portion of the project for her Ph.D. The general goal of this work is to understanding the seasonality of the current internal wave field, and the coupling between the atmosphere, the ice, and the ocean. Such knowledge is critical accurately modeling the upper Arctic Ocean and predict the response of the Arctic Ocean to the increased seasonality observed in recent years.

## RELATED PROJECTS

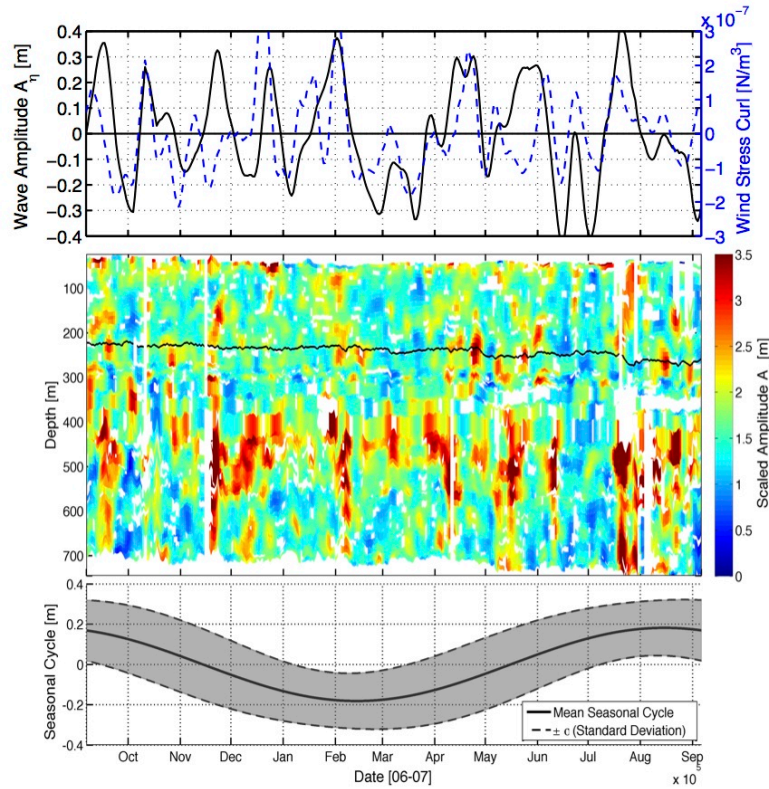
The work conducted by Ms. Dosser as part of this award is closely related to the ONR Arctic DRI on the Emerging Dynamics of the Marginal Ice Zone. As part of the MIZ DRI, Craig Lee and Luc Rainville are planning on deploying several Seagliders in the Arctic in. By collecting observations that span open water, the MIZ and full ice-cover, the gliders will allow to compare and contrast the internal wave field across a range of ice conditions. Ms. Dosser will be involved in the analysis of the MIZ DRI data.

## REFERENCES

Rainville, L., C.M. Lee, and R.A. Woodgate, 2011. Impact of Wind-Driven Mixing in the Arctic Ocean, *Oceanography Magazine*, 24(3):136–145.

## PUBLICATIONS

A publication explaining the technique used to identify the near-inertial signal from the ITPs and describing initial results is almost completed, and will be submitted within a few weeks.



**Figure 1: The middle panel shows amplitude of the vertical displacement due to inertial waves (scaled by the square root of the buoyancy frequency to remove the effects of varying stratification) as a function of time and depth. The depth-averaged amplitude in the top 200 m is plotted on the top panel (black line), along with the magnitude of the wind stress curl averaged over a 200km by 200km box around the ITP location for each day (blue). Both fields have been smoothed using a 7-day low-pass filter. The bottom panel shows the depth-averaged seasonal cycle in amplitude, with the dashed lines indicating one standard deviation from the mean.**